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ABSTRACT

This metric supplement is intended as a guide to aid the industrial arts teacher in incorporating metrics in the classroom. A list of student objectives for measurement skills is followed by an overview of the history of measurement, an argument for change to the metric system in the United States, and a discussion of metric basics (common terms). The next section contains both activities for introducing the metric system, which are written to give students experience using the basic units of metric measure, and pre- and post tests. In the following section the use of metric measurement is covered for these specific areas of industrial arts: drafting, metalworking, woodworking, graphic arts, power/transportation, and electricity/electronics. Each section includes a discussion of where and how changes needed to convert to the metric system should occur as well as suggestions for facilitating the use of metric measurement, sample activities and/or sample problems. A section on converting tools and equipment also contains a list of suggested metric materials for each industrial arts department. A listing of available resources cites sources for books, pamphlets, films/film-strips/slides, kits, posters, charts, periodicals, and supplies and equipment. (YLB)

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ED195757

# USING METRICS

# IN

# INDUSTRIAL ARTS

Developed by

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# All You Will Need to Know About Metric

## (For Your Everyday Life)

# 10

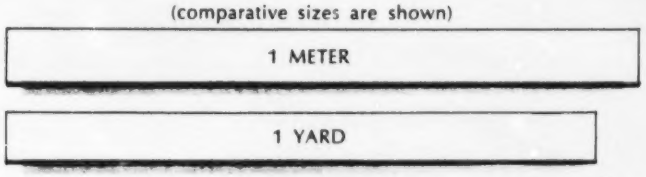
### Metric is based on Decimal system

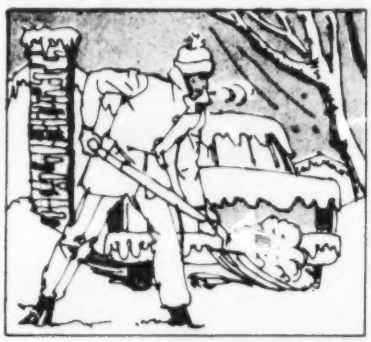
The metric system is simple to learn. For use in your everyday life you will need to learn only ten new units. You will also need to get used to a few new temperatures. There are even some metric units with which you are already familiar: those for time and electricity are the same as you use now.

## BASIC UNITS

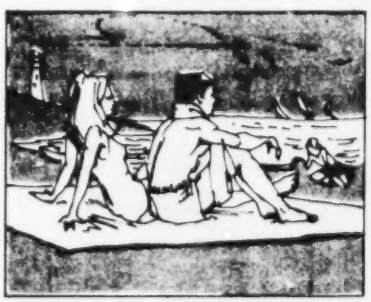
**METER:** a little longer than a yard (about 1.1 yards)
**LITER:** a little larger than a quart (about 1.06 quarts)
**GRAM:** a little more than the weight of a paper clip

(comparative sizes are shown)



25 DEGREES FAHRENHEIT



25 DEGREES CELSIUS

### COMMON PREFIXES
(to be used with basic units)

**milli:** one-thousandth (0.001)
**centi:** one-hundredth (0.01)
**kilo:** one-thousand times (1000)

**For example:**
1000 millimeters = 1 meter
100 centimeters = 1 meter
1000 meters = 1 kilometer

1 LITER

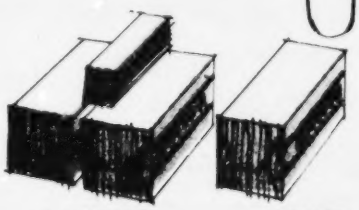
1 QUART

### OTHER COMMONLY USED UNITS

| | | |
|---|---|---|
| **millimeter:** | 0.001 meter | diameter of paper clip wire |
| **centimeter:** | 0.01 meter | a little more than the width of a paper clip (about 0.4 inch) |
| **kilometer:** | 1000 meters | somewhat further than ½ mile (about 0.6 mile) |
| **kilogram:** | 1000 grams | a little more than 2 pounds (about 2.2 pounds) |
| **milliliter:** | 0.001 liter | five of them make a teaspoon |

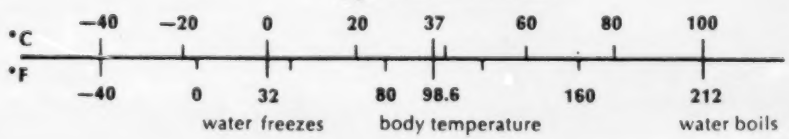
### OTHER USEFUL UNITS

**hectare:** about 2½ acres
**tonne:** about one ton



1 KILOGRAM 1 POUND

### TEMPERATURE
degrees Celsius are used



## FOREWORD

This guide is written for use by the industrial arts teachers in Virginia. It is viewed, not as the answer to all questions concerning metrics, but rather, as a guide to assist the teacher in introducing the metric system of measurement. Hopefully, through the information presented here, the industrial arts teacher will gain enough knowledge and understanding of metrics to feel comfortable with the system.

From this basic understanding and with the activities suggested here, the teacher should be able to introduce metrics in the industrial arts program. From such a simple beginning, students and teachers alike will develop increasing skill as they gain experience with the system.

TABLE OF CONTENTS


| | Page |
|---|---|
| Introduction | 1 |
| Student Objectives | 2 |
| History of Measurement | 3 |
| Why Change Systems | 6 |
| Metric Basics | 9 |
| Activities for Introducing Metrics | 11 |
| Metrics in Industrial Arts | 25 |
| Drafting | 26 |
| Metalworking | 33 |
| Woodworking | 37 |
| Graphic Arts | 42 |
| Power/Transportation | 45 |
| Electricity/Electronics | 47 |
| Converting Tools and Equipment | 48 |
| Available Resources | 52 |

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# INTRODUCTION

The use of metric measurements in the United States appears to be inevitable. Educators should incorporate metric measurement into the classroom as soon as possible. This metric supplement has been prepared to aid the industrial arts teacher in incorporating metrics in the classroom.

Teachers will play a key role in the implementation of a program for conversion to metric. Activities in this supplement are designed to help the teacher as well as the students to learn to "think" metric. The teacher must remember, however, that transition from customary to metric will require time and patience.

The purpose of this guide will be to:

1. Aid teachers in informing students of the advantages of the metric system;
2. Provide the teacher with information to aid students in understanding and executing the mechanics of metric conversion;
3. Provide both teachers and students with a frame of reference for teaching and learning about the metric system;
4. Provide examples of learning experiences to develop a working vocabulary for and practical application of the metric system;
5. Provide sources of materials for classroom use.

## STUDENT OBJECTIVES

The metric system of measurement should not be taught as a separate subject, but should be integrated into the regular industrial arts program. It is hoped that the following list will give guidance in determining measurement skills needed by the general public in present-day society.

The student will be able to:

1. Identify those components of the metric system which are commonly used.
2. Read various instruments scaled metrically.
3. Estimate and measure in centimetres, millimetres and metres.
4. Estimate distance in kilometres.
5. Convert from one metric unit to another.
6. Find the area of a region in square centimetres or square millimetres.
7. Identify the most useful unit for making certain measurements.
8. Estimate and measure using litres and millilitres.
9. Find the mass of object using kilograms and grams.
10. Determine the accuracy and precision of a measurement.
11. Record daily temperatures in degrees Celsius.
12. Solve problems in industrial arts involving metric units of speed.
13. Solve some problems involving metric measures and unit prices.
14. Understand and work with English/metric relationships.

## HISTORY OF MEASUREMENT

Weights and measures were among the earliest tools invented by humans. Parts of the body and natural surroundings for measuring were the first measuring instruments. Early Babylonian and Egyptian records and the Bible indicate that the forearm, hand or finger was used to measure length and the periods of the sun, moon, and other heavenly bodies was used to measure time.

As societies evolved, weights and measures became more complex. The invention of numbering systems and the science of mathematics created systems of weights and measures necessary in trade and commerce. Accuracy became a factor. However, different systems for the same purpose developed and different parts of the world established different systems.

The need for a single, rational, coherent, comprehensive, and internationally accepted system of measurement has long been recognized. Our present customary or English system had its origins in a variety of cultures --Babylonian, Egyptian, Roman, Anglo-Saxon, and Norman French. The ancient "digit," "palm," "span," and "cubit" units evolved into the "inch," "foot," and "yard" through a complicated transformation not yet fully understood. Roman contributions include the use of the number 12 as a base. The "yard" as a measure of length can be traced back to the early Saxon kings. These kings wore a sash or girdle around their waist that could be removed and used as a convenient measuring device.

Tradition holds that King Henry I decreed that the yard should be the distance from the tip of his nose to the end of his thumb. The length of a fur-long (or furrow-long) was established by early Tudor rulers as 220 yards. This led Queen Elizabeth I to declare, in the 16th century, that henceforth the traditional Roman mile of 5,000 feet would be replaced by one of 5,280

feet, making the mile eight furlongs and providing a relationship between two measures.

Thus, through royal edicts, England by the 18th century had achieved a greater degree of standardization than the continental countries. Through colonization and dominance of world commerce during the 17th, 18th, and 19th centuries, the English system of weights and measures was spread to and established in many parts of the world, including the American colonies.

The metric system had its beginnings in France in 1670 when Gabriel Mouton, vicar of St. Paul's Church in Lyons, proposed a decimal system based on a portion of the earth's circumference. Even though a uniform system of weights and measures did not exist in Europe, the metric system was not accepted for more than a hundred years. In 1790, the French Academy of Sciences was asked to create an "invariable standard for all the weights and all the measures," and Mouton's metric system was finally approved. By 1795, the National Assembly of France had adopted the basic format for the metric system and urged other countries to do the same. Many countries displayed an interest and the metric system began to spread.

In 1799, at the end of the French Revolution, the metric system was still only in partial use in France, and in fact, many of the people used their local system of weights and measures. At the beginning of the nineteenth century, Napoleon began to enforce the use of the metric system in France and to introduce it to all of Europe. Through his efforts, many nations in Europe accepted the metric system between 1800 and 1815.

In 1837, France made the use of the metric system in commerical transactions compulsory. The system spread rapidly, coinciding with a new age of technology and science. Because of the increased scientific development, further improvements in international standardization was needed. An international meeting was held in 1872, which resulted in the Treaty of the Metre

of 1875, allowing for metric standards to be constructed and given to each nation signing the treaty. The treaty established a General Conference of Weights and Measures that would meet every six years to consider any changes in the standards.

Between 1851 and 1900, 46 nations accepted the metric system. In the first 50 years of the twentieth century, 22 more nations joined; most of these nations were located in Eastern Europe and the Far East. Today, with the exception of the United States, and a few small nations, the entire world uses the metric system.

Until England went metric in 1965, there was little urgency for the United States to convert. After World War II the United States had dominated the world market for mechanical goods. But England's change left the United States the only major country in the world still using the antiquated system. Metric countries began trading with each other more than with the United States.

In 1968 the Congress passed the Metric Study Act that called for research on the pros and cons of adopting the metric system. As a result, a study entitled, "A Metric America: A Decision Whose Time Has Come" was generated, and a change to the metric system seemed inevitable.

Finally in 1975 Congress passed the Metric Conversion Act. The major provisions of the bill provided for:

- -- Adaptation of the International System of Units (abbreviation SI) as predominant system of measurement units
- -- No specific timetable
- -- Voluntary participation
- -- A Metric Board
- -- Cost of Conversion
  - -- treat as other costs of doing business
  - -- no tax credits or subsidies
  - -- hardship cases to be reviewed by Board

## WHY CHANGE SYSTEMS?

The predominant system of measurement in the United States is called the customary or English system. As the units of this system are unrelated, conversions among units can be a laborious task. The United States inherited its customary system from England, which is currently changing to metrics. Canada is the only other country besides England converting to metrics. When they complete their conversion, the United States will be the only country using this customary system.

More than 90 percent of the world's people use the metric system, making it the dominant language of measurement. The concept of standardization of industrial products in industry originated in the United States with Eli Whitney, and our standards are believed by many to be the best in the world. As many international standards still remain to be developed, the United States can not afford to maintain an isolationist attitude toward international standardization. By going metric, the United States will be able to influence international standards.

This international standardization is closely related to world trade. Our export potential would be enhanced when dual manufacturing is eliminated. At the present time, the United States manufactures one line of products for export and another for use in the United States.

Ultimately, it is in our national best interest to convert to metric. While there is a decided advantage for American industries to "go metric," experience in other countries suggest that the American public will have little trouble mastering the metric system. Most individuals will need to know only three measurement units--meters, liters, and grams. As metric is a decimal system that uses multiples of 10, each basic metric unit can be easily multiplied or divided by factors of 10 to get larger and smaller units.

One author listed the advantages of each system. Advantages of the Customary or English System include:

1. It is easier to do simple arithmetic in your head with customary units using the duodecimal (base twelve) and binary (base two) bases.

2. Computers can handle any base, so why change to a decimal base.

3. Customary units are related to everyday experiences and human anatomy. Metric units are artificial.

4. Metric units are difficult to learn and remember.

5. Changing systems would create mass confusion in the United States, especially to the consumer.

6. Companies would be required to carry double inventories of all parts during the transition period.

7. People would have to be retrained, with a consequent loss in productivity.

8. People might make mistakes when first learning to use the metric system, which would create safety hazards.

9. A conversion program would cost too much.

10. Metrication would be very difficult for small business.

11. The United States may be risking industrial success using the measurement system of countries less technologically developed.

12. Using the metric system in the United States would permit imports from countries not currently manufacturing products to our present customary measurement standards.

13. Our export trade is small and would not benefit significantly if the United States goes metric.

14. The United States is beset by many complex problems, and converting to the metric system would compound our problems.

However, this author's advantages of metric seem to outweigh the advantages of customary:

1. The metric system is used by most nations in the world and is becoming the universal language of measurement.

2. The metric system is simple and the units are logically related to immutable standards. The customary system is antiquated and there is no logical and uniform relationship among the basic units.

3. The metric system eliminates confusion concerning mass, force, and weight.

4. The metric system is easier to learn and use.

5. Conversion to metric would stimulate the economy.

6. Speaking a common language of measurement would greatly improve communication among the world's people.

7. The United States is now at a competitive disadvantage in the world because all other great industrial countries use the metric system or are committed to the change.

8. Computations using metric units are convenient: only a few units and relationships are necessary for use in everyday life.

9. The United States would have greater opportunity and impact in setting international standards in engineering and other areas.

10. The United States is already moving toward increased use of the metric system in an unorganized manner and cost of metrication will increase greatly unless we adopt a coordinated national program for change.

11. The cost and inconvenience of metrication would be temporary, but benefits would continue indefinitely.

12. The metric system is decimally constructed, conforming to our monetary system. Students would not have to spend an inordinate amount of time learning fractions, and the time saved could be used for teaching other important topics.

13. Exports would increase to those countries using the metric system.

14. Superfluous varieties in sizes of products, parts, containers, etc., would be eliminated.

Two systems of measurement will continue to exist in many schools while the transition to SI as the standard units of measurement takes place. The customary units will be placed, due to special needs, in a different role and, with a few exceptions, will eventually evolve into a status of historical or literary references.

## METRIC BASICS

The best way for anyone to become familiar with using the metric system is to acquire the habit of thinking in metric terms. This can be a difficult task for adults who have used the pound, foot, and gallon for many years. Thus, during the transition period from the U.S. customary English system of measurement to the metric system, it may be best if comparisons between the two systems are included. Thus, a metre is a little longer than a yard, a litre is little more than a quart, and a kilogram has a mass of a little more than two pounds.

Some common metric terms include:

Length. The base unit for length is the metre. Units of area and volume are derived from the metre. The square metre ($m^2$), a unit for measuring area, and the cubic metre ($m^3$), a unit for measuring volume, are both derived from the metre.

The kilometer (1000 metres) is used commonly to indicate both highway distance from city to city and the speed of vehicles in kilometres per hour.

The centimeter is one hundredth of a metre. The square centimetre ($cm^2$), a unit for measuring area, and the cubic centimetre ($cm^3$), a unit for measuring volume, are both derived from the centimetre.

The millimetre is one thousandth of a metre and is the common measurement for drafting, machine shop, lumber dimensions, printing industry, steel dimensions, paper dimensions, and piping.

Volume or Capacity. The litre is a measurement of volume or capacity. The litre was not considered a base unit in the International System of Units (SI); however, its continued use as a measurement of metric volume dictates its inclusion as a base unit. It is equivalent to slightly more

than a quart. Items sold by litre are gasoline, milk, juices, wine and any other product measured in liquid volume.

Mass. The kilogram is the base unit for mass and is about 2.2 pounds. Products sold by mass (weight) include items such as meat, cheese, fruit, butter, and nails.

A summary of units commonly used include:

| Quantity | Unit |
|---|---|
| Length | kilometre metre centimetre millimetre |
| Mass | tonne kilogram gram |
| Capacity | litre millilitre |
| Volume | cubic metre cubic centimetre cubic millimetre |
| Area | hectare square metre square centimetre |
| Speed | kilometre per hour |
| Temperature | degree Celsius |

# ACTIVITIES FOR INTRODUCING METRICS

## INTRODUCING THE METRIC SYSTEM

When introducing metrics in the industrial arts program, the teacher should provide experiences that make the learning interesting and fun. They should be developed so that the student can get involved with using metrics. The activities presented here were developed with this in mind.

In using these activities the following procedure is suggested.

1. Give the pre-test to the entire class. When all have answered as many questions as possible, distribute the answer sheets. The student can score their own test. Point out that the pre-test measures the knowledge of the customary or English system in use today in the United States.

2. Divide the class into five work groups. One group will work at each work station, moving round-robin fashion from station to station.

These activities are written to give the students experiences using the basic units of metric measure. On each work sheet there are instructions for the activity station and some questions to give the student experience in calculating using the metric units.

Two or three class periods may be needed for the completion of these activities. The teacher should provide for this in planning the class schedule.

Note that there are several opportunities for the students to estimate using metric figures. This is an important skill to develop. Most Americans can estimate measurements in the customary system, eg., table sizes, room sizes, the weight of an object, the volume of a can. This must be developed in the use of the metric system before people can feel comfortable with metrics.

3. Several introductory activities are provided as for use out-of-class use or as work in class to fill in time. The cubic centimetre, cubic metre, and cubic decimetre constructions help develop concepts of volume. These can be cut from paper, with the cubic metre constructed from metre sticks.

4. The post test can be used to test the students' knowledge of the metric system

---

Correct your answers to the Pre-test:

| | | | |
|---|---|---|---|
| 1. | 2 tablespoons | 10. | 2000 pounds |
| 2. | 1 gill | 11. | 1 pound |
| 3. | 1 cup | 12. | 24 grains |
| 4. | 1 quart | 13. | 1 foot |
| 5. | 1 barrel | 14. | 16-1/2 feet |
| 6. | 128 cubic feet | 15. | 5280 feet |
| 7. | 1 bushel | 16. | 1760 yards |
| 8. | 32 quarts | 17. | 320 rods |
| 9. | 8 quarts | 18. | 27 cubic feet |

Scoring:

18 - 16 correct: CONGRATULATIONS! You really know the customary system, but you'd better get ready for the metric system anyway. It's coming!

15 - 11 correct: PRETTY GOOD! It may be difficult to adjust, but you have only about one-half of what you already know to forget!

10 - 0 correct: LUCKY YOU! You have almost nothing to unlearn. You'll love the metric system!

---

PRE-TEST: Developed by Kathleen Morris at California State University, Long Beach.

ARE YOU READY FOR METRICS? (PRE-TEST)

Please fill in the correct answers:

1. 1 ounce = _____ tablespoon(s)
2. 4 ounces = _____ gill(s)
3. 16 tablespoons = _____ cup(s)
4. 32 ounces = _____ quart(s)
5. 105 quarts = _____ barrel(s)
6. 1 cord = _____ cubic foot/feet
7. 4 pecks = _____ bushel(s)
8. 1 bushel = _____ quart(s)
9. 1 peck = _____ quart(s)
10. 1 ton = _____ pound(s)
11. 16 ounces = _____ pound(s)
12. 1 dram = _____ grain(s)
13. 12 inches = _____ foot/feet
14. 1 rod = _____ foot/feet
15. _____ feet = 1 mile
16. _____ yards = 1 mile
17. _____ rods = 1 mile
18. _____ cubic foot/feet = 1 cubic yard

Work Sheet No. 1

## WEIGHT (MASS) MEASURE

Concept: Items commonly purchased in the grocery store can become a frame of reference for measurement of mass.

Materials: Spring scales
balance
bag of fruit
miscellaneous items to be weighed

1. Weigh out 1 kg of potatoes. (Put in net bag and weigh using spring scales)

   Approximately how many potatoes weigh 1 kg? _____

   What is the average weight of one potato? _____ g

2. How much does the piece of fruit weigh? _____ g

3. How many pieces of fruit would it take to have a mass of 1 kg? _____

4. If this fruit sold for 50¢/kg what would be the cost of each piece?

   $_____

## Work Sheet No. 2

### VOLUME MEASURE

Concept: Relating common volume measures to metric measurements can assist in acquiring a "feel for metric volume measurements".

Materials: Metric measuring cups, full capped drink bottles, empty drink bottles, coffee cup, drinking glass, large container labeled "?", large jar at least 1 litre vol.,

1. Fill the measuring cup with 100 ml water. Pour this into the empty drink bottle.

   Now estimate how many ml in the full drink bottle. _____ ml.

2. To check your estimate, fill the empty drink bottle until it is even with the full bottle. Pour the water back into the measuring cup to measure the content of the bottle.

   What is the volume of the contents of the bottle? _____ ml

   How far off was your guess? _____ ml

3. Fill the tea cup with water as you would in pouring a cup of coffee or tea. Pour the water into a measuring cup. What is the volume of a normal cup of coffee or tea? _____ ml

   Repeat the procedure using the water glass.

   What is the volume of a normal glass of water? _____ ml

4. Fill the jar with exactly 1 litre of water. Using this as a reference, estimate the volume of the large container labeled"?"

   Write your estimate here _____. A prize will be given later for the closest estimate.

## TEMPERATURE

Concept: A feel for celcius measurement of temperature can be gained by comparing fahrenheit and celcius measurements.

Materials: $^{o}F$ thermometers
$^{o}C$ thermometers
bowl of water

1. On the table is a container of water. What is the temperature of the water?

_____ $^{o}F$ _____ $^{o}C$

2. What is the outside temperature?

_____ $^{o}F$ _____ $^{o}C$

3. What is the temperature in this room?

_____ $^{o}F$ _____ $^{o}C$

4. What is the boiling point of water?

_____ $^{o}F$ _____ $^{o}C$

5. What is the freezing point of water?

_____ $^{o}F$ _____ $^{o}C$

## LENGTH MEASURE

Concept: Standard measurements are used in furniture and building construction. These can be used as frames of reference for metric length measurements.

Materials: Metric tape measures, metre stick

1. Measure the table

   Height _____ cm _____ m

   Length _____ cm _____ m

   Width _____ cm _____ m

2. Measure the height of the seat of the chair. _____ cm

3. What is the height of the desk? _____ cm

   _____ m

4. Measure the room.

   _____ m & _____ cm

   How many square meters of carpet would you order for this room?

5. Measure the height of the door. _____ cm

   _____ m

## Work Sheet No. 5

Concept: Body Measurements, when known, can be a frame of reference for other measurements.

Materials: Meter stick, metric tape measure, metric bathroom scales, metric ruler, trundle wheel.

Directions: Estimate your body measurements listed below. Write your estimate in the proper space in the table. Then check your estimate by measuring your body. Enter the actual measurement in the table. Compute the difference between your estimate and the actual measurement.

| | | Estimate | Actual | Difference |
|---|---|---|---|---|
| 1. | Your height ..... | _____ | _____ | _____ |
| 2. | The length of your foot ..... | _____ | _____ | _____ |
| 3. | The width of your finger ..... | _____ | _____ | _____ |
| 4. | The width of your hand ..... | _____ | _____ | _____ |
| 5. | The distance around your waist ..... | _____ | _____ | _____ |
| 6. | The distance around your wrist ..... | _____ | _____ | _____ |
| 7. | The distance around your neck ..... | _____ | _____ | _____ |
| 8. | The distance around your chest ..... | _____ | _____ | _____ |
| 9. | Your weight (mass) ..... | _____ | _____ | _____ |
| 10. | Your head size ..... | _____ | _____ | _____ |
| 11. | Span of hand from tip of thumb to tip of little finger ..... | _____ | _____ | _____ |
| 12. | The distance from the tip of your nose to the tip of your fingers (arm extended) ..... | _____ | _____ | _____ |
| 13. | What is your pace? ..... | _____ | _____ | _____ |
| 14. | The distance from your elbow to the tip of your fingers ..... | _____ | _____ | _____ |

# METRIC WORD SEARCH

C H E K B C M T K O C R U M C R T V W J M C A B
H S K M R M E A S U R E M E N T K M E T R C H V
M D K L M E K W B G R A I C M J I C V E M O E P
P O P C D I B C E N T I L I T E R O T C T K C Z
K G A T E S W P C R K I L O M E T E R P I D T R
B G D O U G C W B M C J I R P A M K O L C W O B
W C E L S I U S V G R A M C Q I R M O R S T M R
J H K Z B R C O S T I T E S T V C G H D C O E P
O E A L C P R D A V I D T N C K R P A M W T T B
O R M A C B E K E R W K E Z R A N D Y K I C E P
P B E R R E T I L D I C R Q M C K D B L E O R C
W E T R B P E R C L K M C W K J L E I P O D C D
R R E Y E E M R O C D K E C O U P C A D A Z B O
E T R E R M Q L B M P B K T R O E I C E A W Q U
O P C G T V I Z I E G U C B R D O M P K R C E G
W G E K M T W L C T E D B J L I M E T A K O H E
J L K O E S L V L R O J E V H E C T O L I T E R
I O E R G I M K M I R U B C R Y W E Q I S G C Z
M Y N G L I I A B C G K R O I K B R E T J O T P
O F B I C B K R O S E R E U P G I U B E U F O O
X C T V Y X E E P A T D A N B Z R O S R D X G Z
H E R B V F K N R A C K V M N Y B A C B Y U R A
R F O D C D C E N T I G R A M Y C D M C A D A Z
P C V A N H R O G E P A S W A K D X C K R Y M B

Locate and encircle the following metric terms in the block above. The words may be horizontal, vertical or diagonal and may be spelled forward or backward.

| | | | | |
|---|---|---|---|---|
| metric | dekameter | decigram | milliliter | hectoliter |
| measurement | hectometer | gram | centiliter | kiloliter |
| meter | kilometer | dekagram | deciliter | Celsius |
| millimeter | milligram | hectogram | liter | |
| centimeter | centigram | kilogram | dekaliter | |
| decimeter | | | | |

26

## METRIC POST-TEST

Attempt to answer the questions without any aids the first time through. Then, you may consult your workshop papers to aid you in answering the following questions:

1. The metric unit used in measuring length is the _____.
2. The metric unit used in measuring mass (weight) is the _____ or _____.
3. The metric unit used in measuring volume (liquids) is the _____.
4. The metric degree of temperature is called _____.
5. To divide any of the basic units into 100 sections, the prefix _____ is used.
6. To divide any of the basic units into 1000 sections, the prefix _____ is used.
7. To multiply a basic unit by 1000, we use the prefix _____.
8. Driving distance would be measured by _____.
9. The approximate distance from the tip of <u>your</u> thumb to the tip of your little finger is _____ cm.
10. Using your "body rulers" the width of this paper is approximately _____ cm.
11. Normal body temperature is _____ $^{o}C$.
12. How much did you weigh? _____ kg
13. How tall were you? _____ cm
14. What is the seam allowance on a pattern? _____ cm
15. What is comfortable room temperature? _____ $^{o}C$.

## FRACTIONS OF AN INCH TO MILLIMETRES

| in | | mm | in | | mm | in | | mm | in | | mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/64 | 0.016 | 0.397 | 17/64 | 0.266 | 6.747 | 33/64 | 0.516 | 13.097 | 49/64 | 0.766 | 19.447 |
| 1/32 | 0.031 | 0.794 | 9/32 | 0.281 | 7.144 | 17/32 | 0.531 | 13.494 | 25/32 | 0.781 | 19.844 |
| 3/64 | 0.047 | 1.191 | 19/64 | 0.297 | 7.541 | 35/64 | 0.547 | 13.891 | 51/64 | 0.797 | 20.241 |
| 1/16 | 0.062 | 1.588 | 5/16 | 0.312 | 7.938 | 9/16 | 0.562 | 14.288 | 13/16 | 0.812 | 20.638 |
| 5/64 | 0.078 | 1.984 | 21/64 | 0.328 | 8.334 | 37/64 | 0.578 | 14.684 | 53/64 | 0.828 | 21.034 |
| 3/32 | 0.094 | 2.381 | 11/32 | 0.344 | 8.731 | 19/32 | 0.594 | 15.081 | 27/32 | 0.844 | 21.431 |
| 7/64 | 0.109 | 2.778 | 23/64 | 0.359 | 9.128 | 39/64 | 0.609 | 15.478 | 55/64 | 0.859 | 21.828 |
| 1/8 | 0.125 | 3.175 | 3/8 | 0.375 | 9.525 | 5/8 | 0.625 | 15.875 | 7/8 | 0.875 | 22.225 |
| 9/64 | 0.141 | 3.572 | 25/64 | 0.391 | 9.922 | 41/64 | 0.641 | 16.272 | 57/64 | 0.891 | 22.622 |
| 5/32 | 0.156 | 3.969 | 13/32 | 0.406 | 10.319 | 21/32 | 0.656 | 16.669 | 29/32 | 0.906 | 23.019 |
| 11/64 | 0.172 | 4.366 | 27/64 | 0.422 | 10.716 | 43/64 | 0.672 | 17.066 | 59/64 | 0.922 | 23.416 |
| 3/16 | 0.188 | 4.762 | 7/16 | 0.438 | 11.112 | 11/16 | 0.688 | 17.462 | 15/16 | 0.938 | 23.812 |
| 13/64 | 0.203 | 5.159 | 29/64 | 0.453 | 11.509 | 45/64 | 0.703 | 17.859 | 61/64 | 0.953 | 24.209 |
| 7/32 | 0.219 | 5.556 | 15/32 | 0.469 | 11.906 | 23/32 | 0.719 | 18.256 | 31/32 | 0.969 | 24.606 |
| 15/64 | 0.234 | 5.953 | 31/64 | 0.484 | 12.303 | 47/64 | 0.734 | 18.653 | 63/64 | 0.984 | 25.003 |
| 1/4 | 0.250 | 6.350 | 1/2 | 0.500 | 12.700 | 3/4 | 0.750 | 19.050 | 1 | 1.000 | 25.400 |

## TRUNDLE WHEEL

- This device may be used for measuring longer distances such as classroom floor spaces, corridors or playground areas. It is also used to show the relationship between the circumference and the diameter of a circle.

- Trundle wheels may be constructed with woodscraps; the only critical dimension is the wheel itself. A circle 31.8 cm in diameter should be cut from 3/8" or 1/2" plywood (approximately 13" x 13")

- Trundle wheels may be purchased.

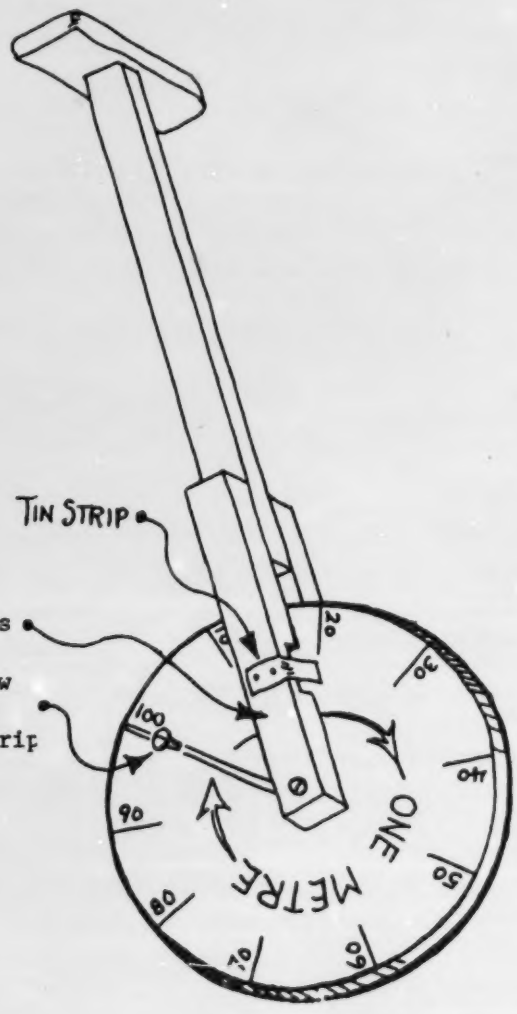
- To find the diameter of a circle with a circumference of 1 metre (or 100 cm)

$$c = \pi d$$

$$100\text{cm} = 3.14\ d$$

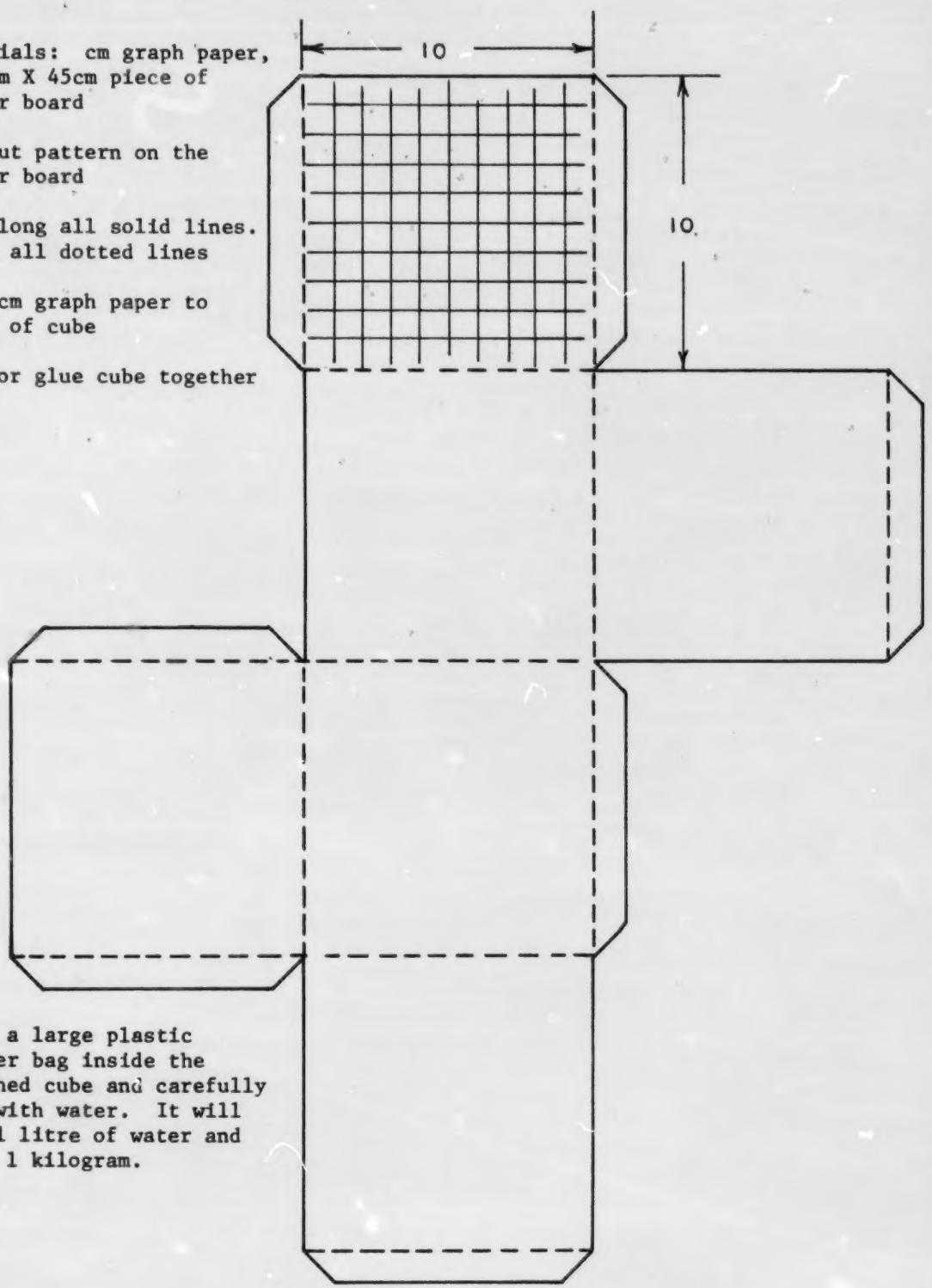
$$\frac{100}{3.14} = d$$

$$31.8\text{cm} = d$$



## CUBIC DECIMETRE

- Materials: cm graph paper, a 35cm X 45cm piece of poster board
- Lay out pattern on the poster board
- Cut along all solid lines. Score all dotted lines
- Glue cm graph paper to sides of cube
- Tape or glue cube together




- Place a large plastic freezer bag inside the finished cube and carefully fill with water. It will hold 1 litre of water and weigh 1 kilogram.

# METRICS

# IN

# INDUSTRIAL ARTS

## DRAFTING

As drafting is considered the universal language of industry, students should become familiar with the use of metrics in this area. With the exceptions of scales and templates, and paper size, little change is needed to convert to metric drafting. A conversion table including inches to centimeters may be useful.

The most important tool is the scale. Metric linear measure is the most important aspect of metrics in regard to drafting. Hence, a knowledge of metric scales is essential. Specific rounding rules and linear sizes are necessary for uniform metric design. From the English to the metric system, the use of conversion charts is suggested.

Certain types of metric templates will facilitate faster drawing in metric sizes. Such templates as circle, ellipse, isometric, hexagon nuts and bolts, screw thread, and radius guide would be very helpful.

The change to the metric system of weights and measures is less urgent in construction and related fields than in manufacturing since international trade is less involved. It will be some years before the all metric house can be built. Before this could happen all basic materials and components including lumber, panel stock, brick, cement block, insulation, roofing materials, windows, doors, shutters, and all others must be available in metric modules based on 100 mm. A hard conversion in the building industry will depend on the establishment of metric standards for all materials and building components.

In building construction soft conversion from customary to metric sizes is of no value in itself and could be a waste of time. The nominal sizes of customary materials such as the familiar 2" x 4" framing material

or the 4' x 8' panel are good examples. If these were converted directly to metric units, complex and unnecessary size designations would result. While there might be some educational value in showing equivalent metric sizes of customary materials, the practice could only complicate building construction.

While little change will be found in the drafting practices, some changes do occur in dimensioning and notations. A modern drafting text book that includes metric conventions should be used as a reference.

Students will usually use the A4 ( 210 mm x 297 mm ) and the A3 (297 mm x 420 mm ) paper sizes. See pages 43 and 44 of this guide for an explanation of metric paper sizes. These paper sizes will closely approximate the customary sizes now commonly used.

Several metric drafting practices are listed below. They represent major changes from the customary system that the student in a basic drafting course will encounter.

... Use whole numbers and decimals. Fractions are not used in metric notation.

... In machine drafting measurements are given in millimetres for all dimensions even though the numbers may seem quite large.

... No comma is used when writing figures larger than one hundred. A space is left where the comma is used in customary numbers.

For example: 43 526 is correct. ( 43,526 is INCORRECT)

... If it is necessary to show metric and customary measurements on a drawing, the customary measurements should be listed along with their comparable metric values in a table on the side on the drawing.

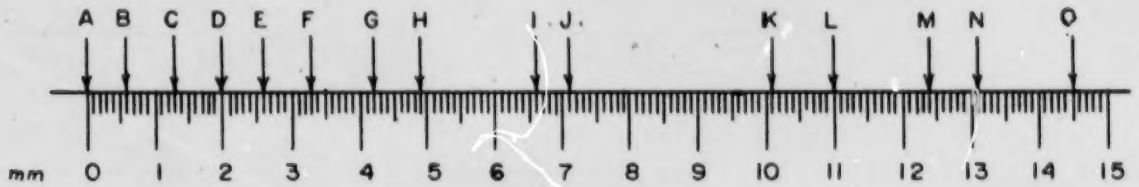
... The metre is generally used as the unit of measure for large areas such as maps. plot plans and for architectural structures.

... The symbol Ø is used for "diameter".

Class _____ Date _____ Name _____

Part II

Read each of the following measurements and letter the answer in the space provided. Check the answer with a metric scale whenever you wish. Each length is a multiple of millimeters.



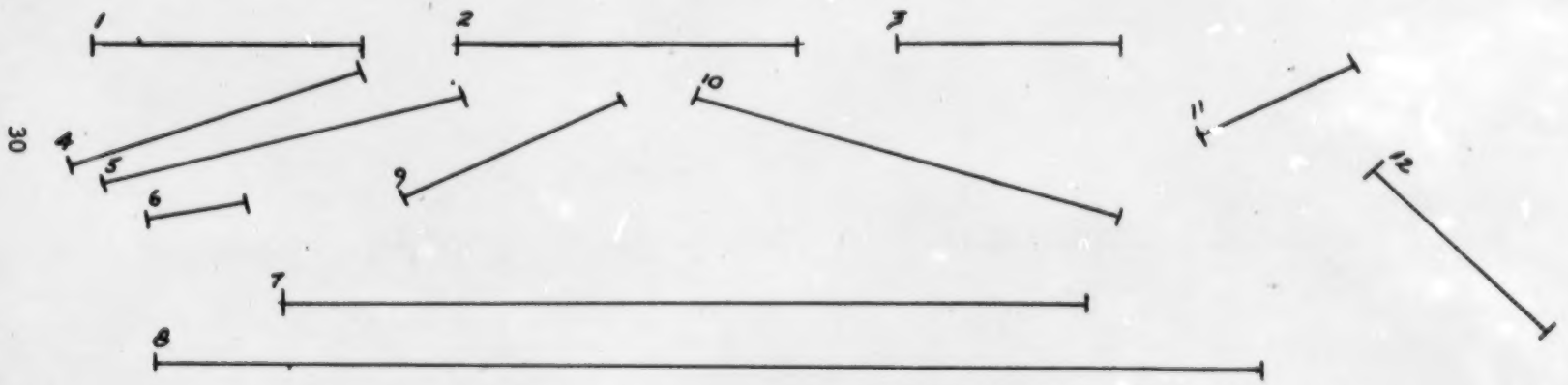

1. A to B is _____
2. A to C is _____
3. A to D is _____
4. A to E is _____
5. A to F is _____
6. A to G is _____
7. A to H is _____
8. A to I is _____
9. A to J is _____
10. A to K is _____
11. A to L is _____
12. A to M is _____
13. A to N is _____
14. A to O is _____
15. C to G is _____
16. E to H is _____
17. F to N is _____
18. N to O is _____

## ACTIVITY FOR METRIC MEASUREMENTS

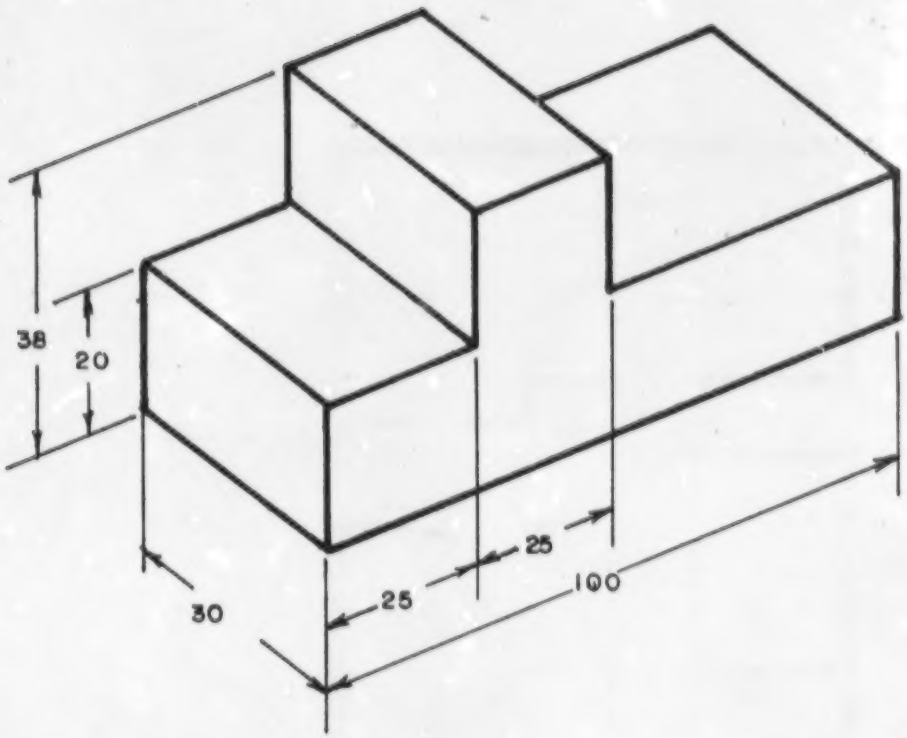
Class _____ Date _____ Name _____

Part I

The length of each of the lines below is a multiple of five (5) millimeters. Measure each line with a metric scale and letter the answer on the line.

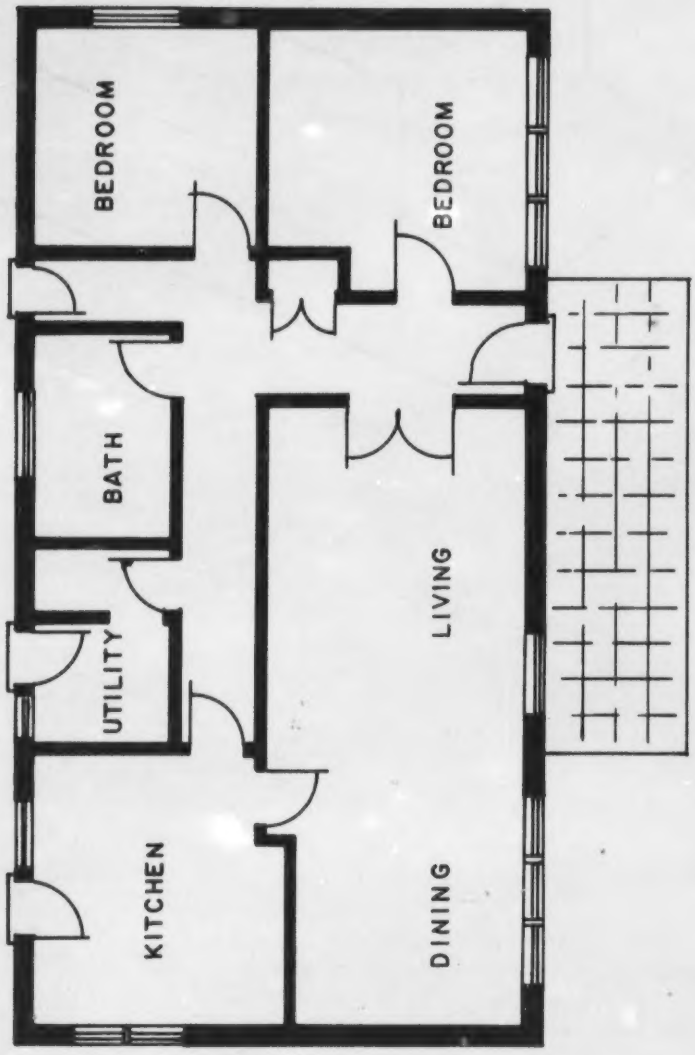


SAMPLE PROBLEMS




Draw and fully dimension the item above. Draw third angle multi-view, isometric and cabinet drawings to scale.

ARCHITECTURAL PROBLEM




INSTRUCTIONS: Draw this floor plan using appropriate dimensions scale and symbols. Lay out the utilities and furniture for most efficient use of the rooms.

41

## METALWORKING

The metalworking area will experience some change including several common measuring tools. In all metalworking areas, the following metric units will be commonly used: (1) millimetre for thickness and width and millimetre or metre for length measurements; (2) kilogram for basic weight (mass)--the metric ton may be used for the sale of bulk products; (3) heat will be given in degrees Celsius; (4) stress will be given in multiples of the pascal, principally in megapascals (MPa) and gigapascals (GPa).

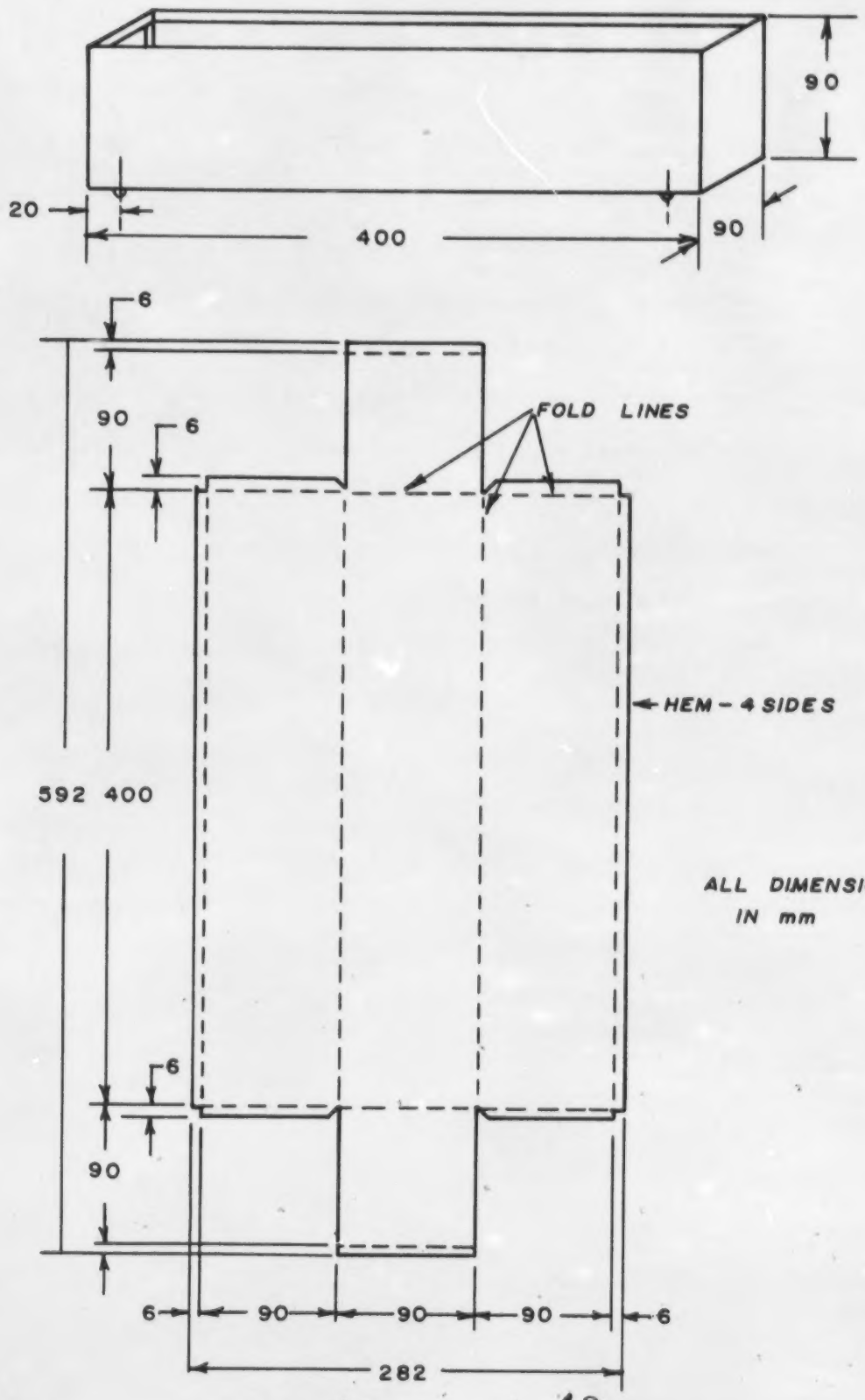
Metal stock items such as sheets, strips, bars, wire and all other standard items vary with the kind of material as well as the metal in it. As a temporary measure, plastic metric tape can be attached to or over the customary gages. All sheet metal products will give dimensions in full or rounded millimeters.

The common metric measuring tools include metric rules or scales, micrometers, verniers, feeler gages, and other measuring instruments such as dial indicator gages. All of these items must be replaced in order to do metric metalworking.

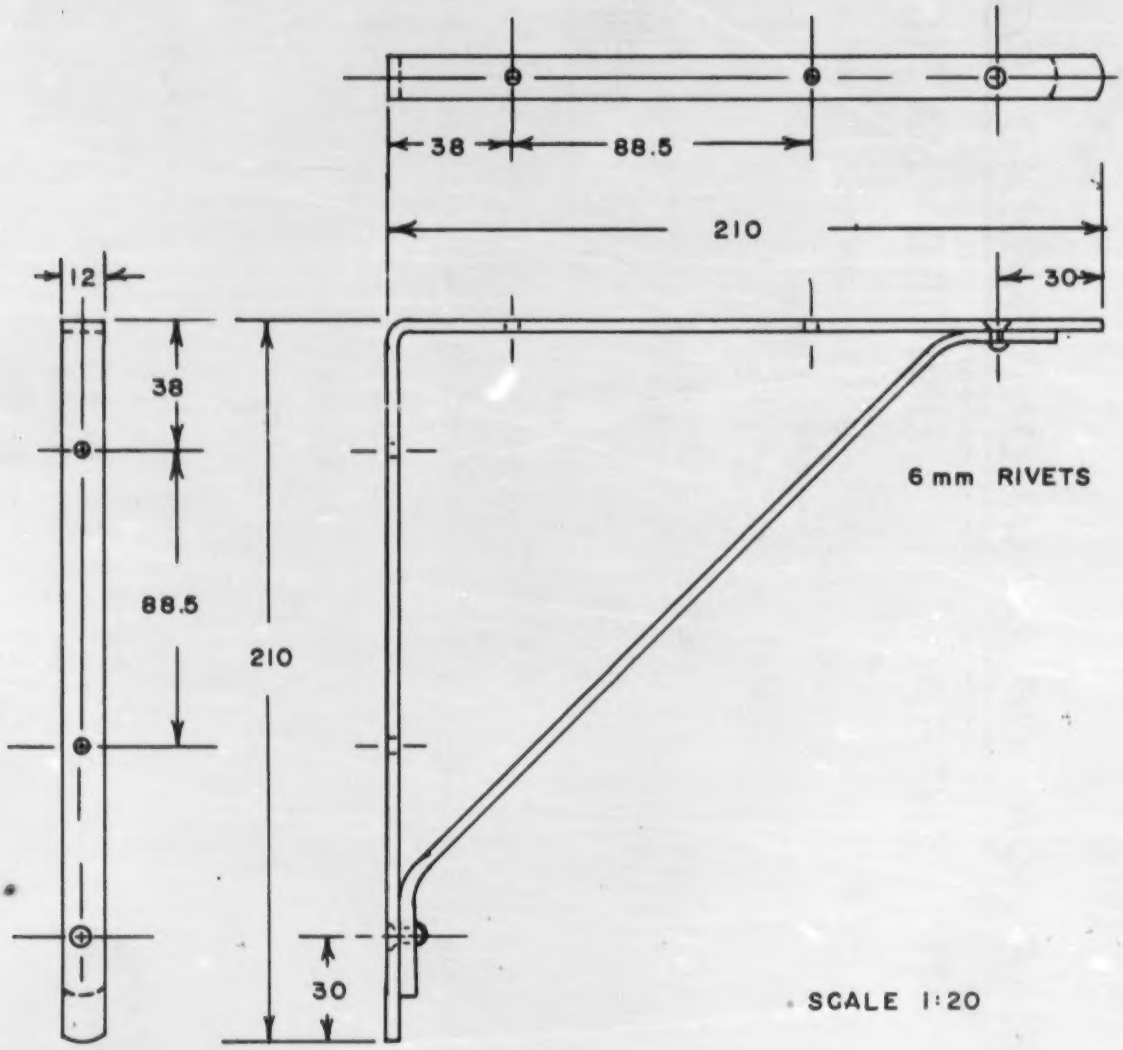
Major changes in foundry will include the following: (1) Weight (mass) of materials will be given in kilograms; (2) Foundry heats will be given in degrees Celsius; (3) Metric shrink rules will be used for foundry patterns.

Metric threads will come in two basic types: (1) the ISO metric series and the ISO inch. While the shape is identical, they are not compatible.

# SHEET METAL BOX



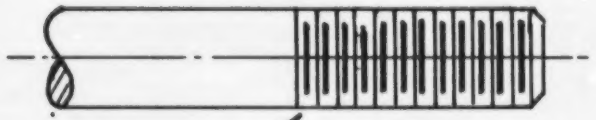
# SHELF BRACKET



# COMPARISON OF COMMON THREAD SIZES

## ISO METRIC THREAD

COARSE THREAD SERIES



M8 x 1.25 - 6g

THREAD SYMBOL

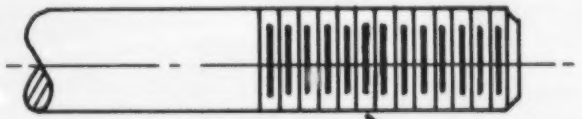
NOMINAL SIZE IN mm

PITCH IN mm

THREAD TOLERANCE CLASS SYMBOL

## UNIFIED NATIONAL

COARSE THREAD SERIES



5/16 - 18 UNC - 2A

MAJOR DIAMETER

THREADS PER INCH

THREAD SERIES

CLASS

| ISO METRIC | UNIFIED NATIONAL |
|---|---|
| 24 x 3 | 1-8 |
| | 7/8-9 |
| 20 x 2.5 | 3/4-10 |
| 16 x 2 | 5/8-11 |
| | 9/16-12 |
| 12 x 1.75 | 1/2-13 |
| | 7/16-14 |
| 10 x 1.5 | 3/8-16 |
| 8 x 1.25 | 5/16-18 |
| | 1/4-20 |
| 6 x 1 | 12-24 |
| 5 x .8 | 10-24 |
| 4 x .7 | 8-32 |
| | 6-32 |
| 3 x .5 | 5-40 |
| | 4-40 |
| 2.5 x .45 | 3-48 |
| | 2-56 |
| 2 x .4 | |

## WOODWORKING

Metric measurement in the wood industry will produce many changes. Building plans and the construction industry will be affected but to a slower extent due to the fact that it is generally a local (U.S.) industry.

Of more immediate importance will be conversion of lumber and measuring tools used for woodworking. Lumber will be measured in millimeters (mm) for thickness and width and in meters (M) for length. It will be sold by the cubic meter ($M^3$) instead of the board foot. Exotic hardwoods will be sold by weight or kilograms (kg).

As for plywood, particle board, and other types of material, it is felt that they will remain the same size due to replacement needs in older structures. A 4' x 8' sheet of plywood, for example, would become a 1220 mm X 2440 mm panel (1219.2 X 2438.4 rounded off).

In summary, the meter will replace the foot, the centimeter will replace the inch, and the millimeter will replace the fraction of an inch.

By knowing and understanding some simple metric practices, the woodworking teacher can acquire facility in helping students to work out metric problems. Woodworking machines need not be replaced. Instead, one can make a simple conversion by applying metric tape along side existing customary scales on machines.

The measuring tools used in woodworking will have to be replaced gradually as customary tools wear out. It is a good idea to get tools that have a dual capacity. Most of the other tools, however, will not have to be replaced. In the future, they will be specified according to metric instead of customary sizes.

Simple wood projects designed according to metric dimensions will help the students acquire a feeling for metric measurements. Architectural drawing will be somewhat influenced by lumber standards.

Customary fasteners and hardware items will be used for many years in woodworking programs. Such items as wood screws, nails, hinges, drawer pulls, etc., will not be affected for some time by metric conversion. However, as customary drills are replaced by metric drills, the teacher will find it necessary to use these for boring pilot and shank holes for wood screws. A conversion chart, such as the one found on the following page, will aid in this situation.

The woodworking organizations in the United States are not presently involved in writing new metric standards for wood products. This is a task which will face them in the future.

The use of metric measurement in woodworking can be facilitated by initiating the following suggestions:

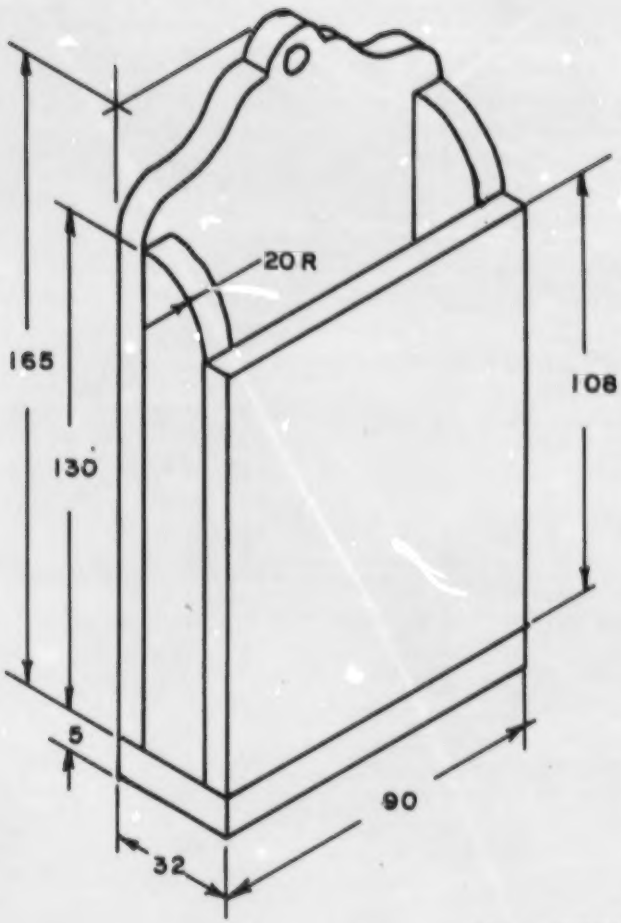
1. Develop a thorough understanding of metrication and compile a resource unit of current materials, films, and visuals on metrics.
2. Purchase metric tools when replacing measuring tools.
3. Develop dual scales for equipment or obtain them through manufacturers.
4. Make conversion charts for materials amounts and costs available to students.
5. Provide a number of projects which are completely designed and constructed for metric scale drawings.

## BORING CHART FOR WOOD SCREWS

### Customary and Metric Sizes

| No. of Screw | Max. Head Dia. Inch | SHANK DIAMETER | | | ROOT DIAMETER | | | Thread per Inch | No. of Screw |
|---|---|---|---|---|---|---|---|---|---|
| | | Basic Dec. Size Inch | Nearest Drill Equivalent Inch | mm | Average Dec. Size Inch | Nearest Drill Equivalent Inch | mm | | |
| 0 | .119 | .060 | 1/16 | 1.5 | .040 | 3/64 | 1.0 | 32 | 0 |
| 1 | .146 | .073 | 5/64 | 2.0 | .046 | 3/64 | 1.0 | 28 | 1 |
| 2 | .172 | .086 | 3/32 | 2.5 | .054 | 1/16 | 1.5 | 26 | 2 |
| 3 | .199 | .099 | 7/64 | 3.0 | .065 | 1/16 | 1.5 | 24 | 3 |
| 4 | .225 | .112 | 7/64 | 3.0 | .075 | 5/64 | 2.0 | 22 | 4 |
| 5 | .252 | .125 | 1/8 | 3.5 | .085 | 5/64 | 2.0 | 20 | 5 |
| 6 | .279 | .138 | 9/64 | 3.5 | .094 | 3/32 | 2.5 | 18 | 6 |
| 7 | .305 | .151 | 5/32 | 4.0 | .102 | 7/64 | 2.5 | 16 | 7 |
| 8 | .332 | .164 | 5/32 | 4.0 | .112 | 7/64 | 2.5 | 15 | 8 |
| 9 | .358 | .177 | 11/64 | 4.5 | .122 | 1/8 | 3.0 | 14 | 9 |
| 10 | .385 | .190 | 3/16 | 5.0 | .130 | 1/8 | 3.0 | 13 | 10 |
| 11 | .411 | .203 | 13/64 | 5.5 | .139 | 9/64 | 3.5 | 12 | 11 |
| 12 | .438 | .216 | 7/32 | 5.5 | .148 | 9/64 | 3.5 | 11 | 12 |
| 14 | .491 | .242 | 1/4 | 6.5 | .165 | 5/32 | 4.0 | 10 | 14 |
| 16 | .544 | .268 | 17/64 | 7.0 | .184 | 3/16 | 4.5 | 9 | 16 |
| 18 | .597 | .294 | 19/64 | 7.5 | .204 | 13/64 | 5.0 | 8 | 18 |
| 20 | .650 | .320 | 5/16 | 8.0 | .223 | 7/32 | 5.5 | 8 | 20 |
| 24 | .756 | .372 | 3/8 | 9.5 | .260 | 1/4 | 6.0 | 7 | 24 |

# LETTER HOLDER

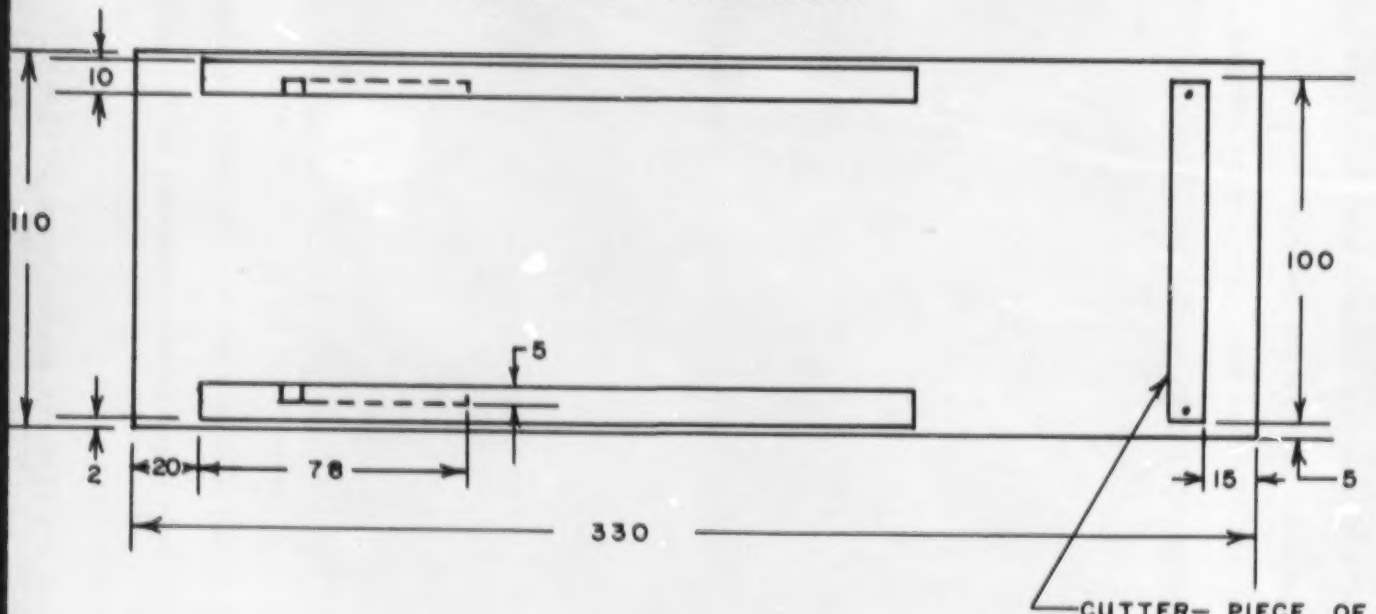


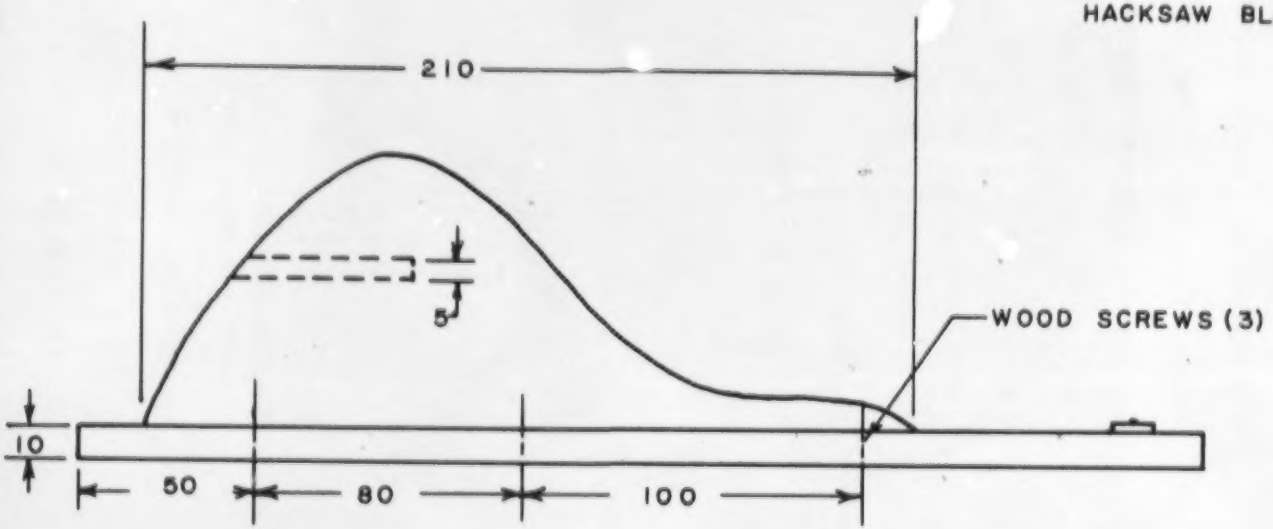

DIMENSIONS IN mm

ALL STOCK 5mm THICK

50

# MEMO BOARD


10
110
5
2
20
78
100
15
5
330
CUTTER– PIECE OF HACKSAW BLADE


210
5
WOOD SCREWS (3)
10
50
80
100

## GRAPHIC ARTS

Conversion to the metric system will affect graphic arts both directly and indirectly. Metric conversion will necessitate certain changes in photography, paper, envelopes, microfilm, cold type layout and packaging. Because most paper has printing of some kind on it, metric conversion will require that additional information on metric weights be included. During the early stages of conversion, labels and cartons show dual measurement with both customary measurements and the metric equivalents. Eventually, most products will be available in rounded metric sizes. Hot type printing (letterpress) will not be affected by metric conversion. The reason for this is that a hard conversion of this machinery and the type sizes would be too costly.

The International Standards Organization's (ISO) units of measurement that apply to graphic arts are listed below:

Metre--linear measure used for press, film, paper, and plate size designations

Kilogram--mass measure used for press weights and bulk powder dark room chemicals

Litre--volume measure used for dark room chemical

Celsius--temperature measurement used for developers and ph solutions

The ISO paper sizes are based on square metre ($m^2$). The AO size paper is 841 x 1189 mm which is nearly a square metre. Its ratio of length to width is 1 : 2 or 1 : 1.414. This ratio remains constant as it applies to all ISO sizes in the "A" series.

Paper weight will be based on the gram per square metre or ($g/m^2$). Any paper base may be converted as follows: $\frac{\text{(Base weight) x (1406)}}{\text{inch}^2 \text{ per sheet}} = g/m^2$

Halftone line screen are shown in centimeters or inch, and many carry both cm and inch designations. The "Line Cross" shows a screen of 35 cm or 85/inch line screen.

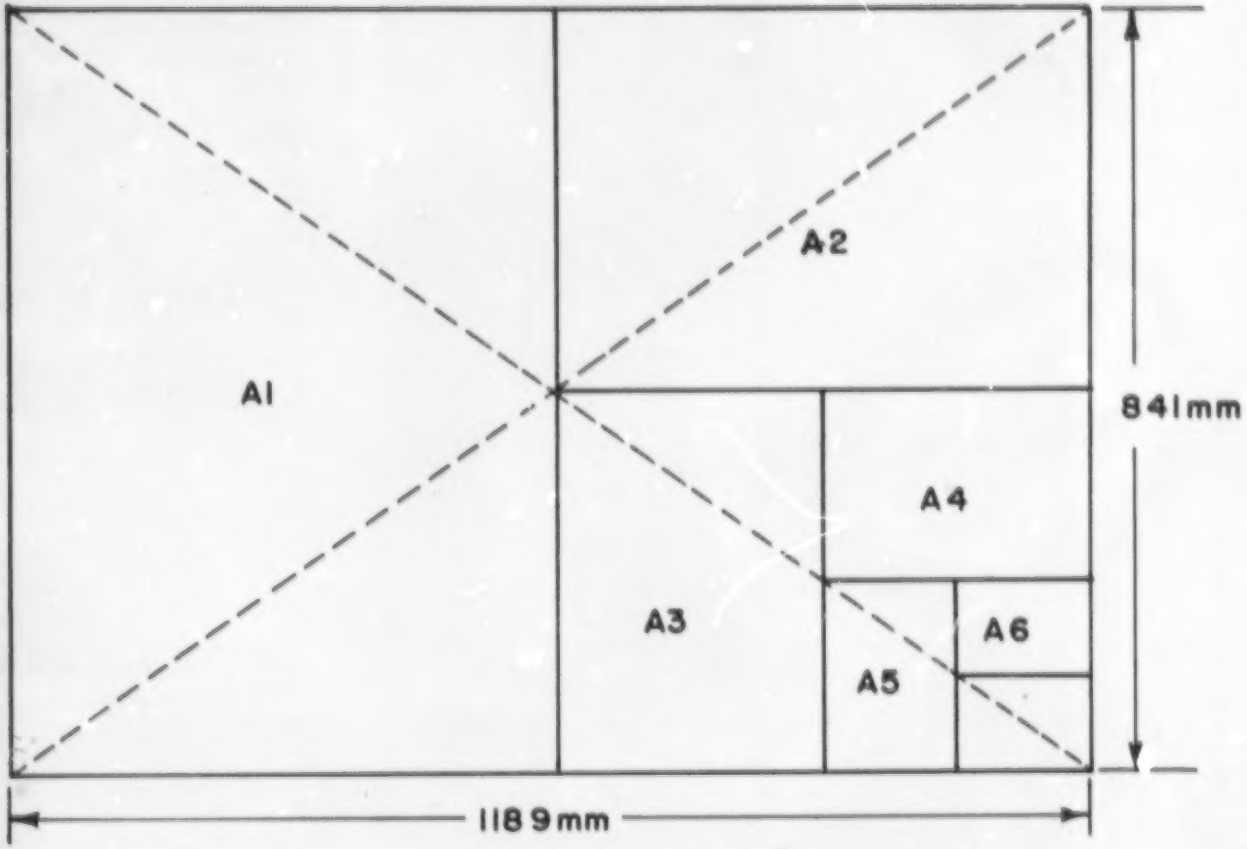
The easiest solution to the problem of type sizes would be to make "soft" conversions (e.g., 6 pt. type would be 6 x .3514 or 2.109+mm). This would merely relabel the sizes in mm instead of points.

Photography is one area in which metric has been used for many years. Metric units are used to describe many film sizes, lens sizes, focal length, and photography mixtures. This is natural, since many kinds of cameras were originally developed in traditional metric countries. For example, the 35 mm camera was designed in 1914 by Oskar Barnack, a German engineer. Movie cameras and film have traditionally been produced in 8 mm, 16 mm, and 35 mm sizes.

COMPARISON OF A-SIZE PAPER

| ISO Sizes | Metric - mm | Customary - inches |
|---|---|---|
| 2A | 1189 x 1682 | 46.81 x 66.22 |
| A0 | 841 x 1189 | 33.11 x 46.81 |
| A1 | 594 x 841 | 23.39 x 33.11 |
| A2 | 420 x 594 | 16.54 x 23.39 |
| A3 | 297 x 420 | 11.69 x 16.54 |
| A4 | 210 x 297 | 8.27 x 11.69 |
| A5 | 148 x 210 | 5.83 x 8.27 |
| A6 | 105 x 148 | 4.13 x 5.83 |
| A7 | 74 x 105 | 2.91 x 4.13 |
| A8 | 52 x 74 | 2.05 x 2.91 |
| A9 | 37 x 52 | 1.46 x 2.05 |
| A10 | 26 x 37 | 1.02 x 1.46 |

# ISO - A PAPER SIZE




1189mm x 841mm = 1 SQUARE METRE

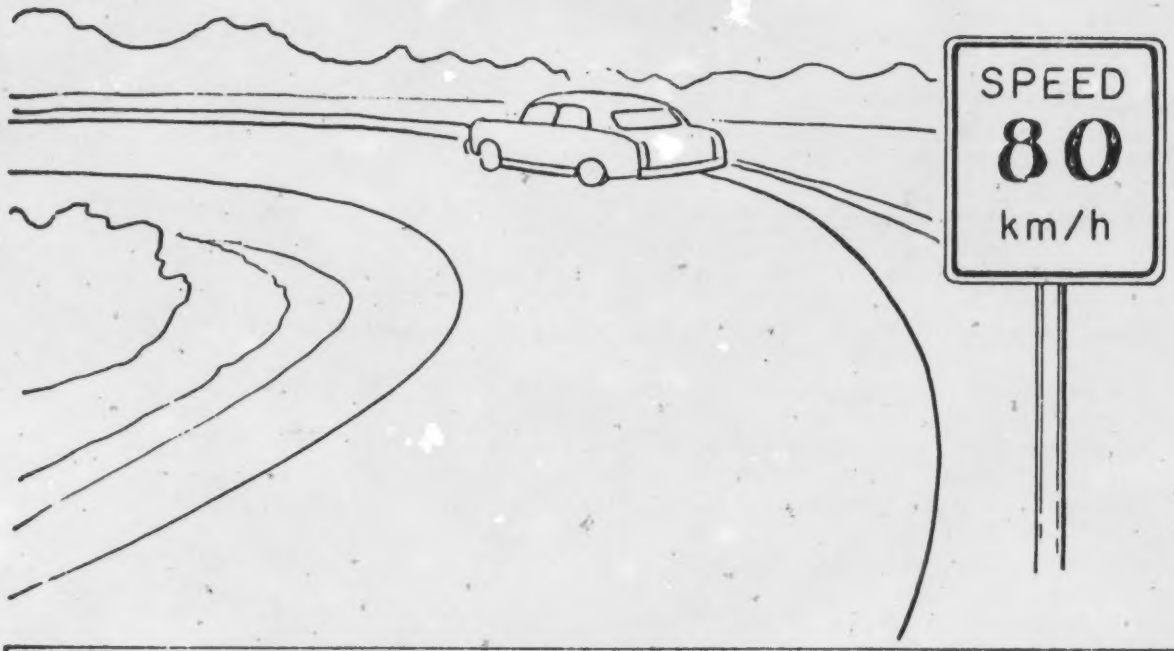
Auto Mechanics

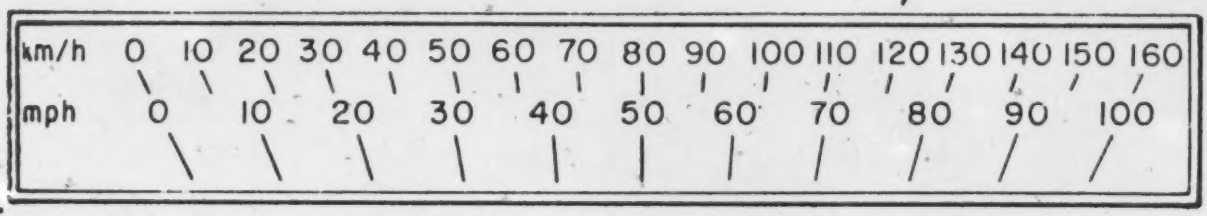
Metric conversion will affect manufacturing, servicing, and customer use of automobiles in many ways. New American automobile designs will utilize materials produced to metric modules, ISO threads, and other standard metric units. During the early stages of conversion, engine development and manufacturing will be affected the most. Conversion to all metric measurement and standards will be a slow and gradual process extending over many years and will depend to a large extent on the availability of metric materials and components. A large number of metric standards will be needed for such things as hose, gears, glass, splines, and innumberable other items. About 30 percent of all cars in use now in the United States have ISO threads. Wheel sizes will not change since the customary standards for these items are now used worldwide.

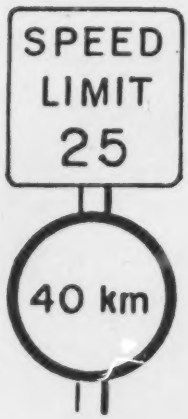
Other changes will include a dual reading speedometer showing speeds in miles per hour and kilometers per hour, cars with metric engines have the users' handbook written in metric language, all units involving liquid are specified in liters (the size of the gas tank, oil capacity, and collant required), tire pressure is given in kilopascals, speed limit signs will show speeds in kilometers per hour using the symbol km/h, and average stopping distance will be in meters at various speeds.

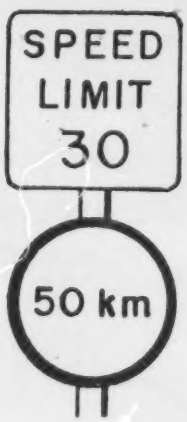
Only those hand tools dealing with direct measurement must be changed.

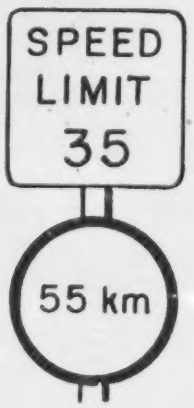
# SPEED


SPEED
80
km/h


km/h 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
mph 0 10 20 30 40 50 60 70 80 90 100


SPEED
LIMIT
25
40 km


SPEED
LIMIT
30
50 km


SPEED
LIMIT
35
55 km

## ELECTRICITY/ELECTRONICS

Since the unit of measure (ampere, ohm, volt, and watt) remain unchanged under the metric system, few changes are necessary in this area. With the adoption of the SI many of the units that have been in use for years in electricity/electronics were adopted for use by all areas of technology. Some new electrical units were introduced to replace older metric units previously used in electricity-electronics. An example would be:

Unit--Watt
Symbol--W
Definition--The watt is the power which gives rise to the production of energy at the rate of one joule per second (J/s)

In the United States the watt has always been used for electrical power only; however, under the SI system it will be the only unit of power including all forms of mechanical power. The watt is a much more practical and realistic unit. For example, if an electric motor consumes 20 KW power and has an output rating of 18 KW, its efficiency in 90 percent.

Therefore, the area of electricity and electronics has not been covered in detail since the units of measure remain the same in the metric system.

## CONVERTING TOOLS AND EQUIPMENT

As machines do not have measuring capabilities, the conversion of most machines is not as expensive as many individuals argue. Machines can cut, shape, and form in inch or metric dimensions.

For the industrial arts lab the major cost for metric conversion would be dual reading dials and other measuring devices. After listing and determining which measuring capabilities need conversion, an immediate conversion can be done by simply adding a metric measurement scale. Since there will be a continuing need to measure in inches for several years, replacement of machinery can be gradual.

Some simple hand measuring tools will need replacement, others having both inch and metric measurements on them can continue to be used.

In summary, only those hand tools dealing with direct measurement must be changed. The machine tools and other equipment can be temporarily converted by adding metric divisions to the existing inch scales. The conversion is 1 inch = 25.40 mm or 2.54 cm.

Hand tools. Only those hand tools that have to do with direct measurement will be changed. Scales and other simple measuring equipment should be purchased with dual markings, whenever possible. New micrometers and similar equipment should be purchased in metric units, but the older equipment should be retained. As tools are gradually phased out, stocks of small tools, taps, dies, allen wrenches, radius gages, feeler gages, broaches, and other tools will have to be provided in metric standards.

Measuring Tools. All woodworking measuring tools will need to be replaced with metric measuring tools. However, many of the measuring tools, particularly items such as flexible rule, are already marked with

dual dimensions; one side that reads in inches and the other in centimeters and millimeters.

Boring tools will not need to be replaced, since these will have only a soft conversion. All existing toolholders, chucks, jigs, fixtures, clamping devices and collet should be examined to determine their usefulness. If deemed useful, steps should be taken to make them suitable for the metric system.

It is a simple matter to convert a paper cutter for cutting paper to metric sizes. The flexible metal tape for setting the depth is available with a dual reading scale.

Existing machine, tools and equipment. Equipment should be surveyed to determine its age, condition, complexity, frequency of use, type of work performed, and likelihood of replacement. Determination must be made whether to retain the equipment, using it "as is," or to convert it to dual use or to convert completely to metric scale. Some conversion kits are available.

Changing the lead screw in a lathe, as well as the dial, is another possibility, but is likely to be more costly and is not really necessary if a dial conversion unit can be obtained. In the purchase of new equipment for expansion or replacement of that which has outlived its usefulness, consideration of dual system equipment should be given high priority.

One of the simplest methods of converting a machine tool would be to add metric divisions to existing inch dials. For example, if the feed screw has a 4TPI, one revolution of the handwheel and feed indicator represents .250" or 6.35 mm. In this case, the back edge of the dial is graduated in increments of 0.02 mm and another zero pointer is added. Exact conversion is 1" = 25.40.

Since woodworking is not a precise craft like metalworking, the problem of converting these machines is relatively easy. Most woodworking machines have adjustments for depth and width of cut with a scale in the customary units. Metric conversion can be made by adding pressure-sensitized metric tape cut to suitable lengths adjacent to the customary gage or scale.

All large equipment can be converted with digital reading equipment. The use of pyrometers and other equipment with degree Celsius temperature scales can be used for heat treating.

The following is a list of suggested metric materials that may be provided for each industrial arts department.

Metric wall chart
Single beam balance scale
Demonstration metre stick
Measuring tape, 1.5 metres
Student ruler (pkg. 10)
Metric volume set
Metre stick (pkg. 10)
Celsius student thermometer (pkg. 10)

In addition to the above, it is highly recommended that the following filmstrips be purchased by the audiovisual departments for use by all persons interested in teaching the metric system of measurement.

Metric Measurement Length.
Metric Measurement Weight.
Metric Measurement Liquid Capacity.

Additional items needed in specific areas are listed below.

Drafting

Scales, 300 mm
Circle templates up to 55 mm

Metals

Scales, 150 mm
Try scales, 152 mm
Tap and die screw plate set

Power Mechanics

Gauges
  Temperature
  Gas
  Air
Odometer--speed
Information of tire sizes
Common road signs

Wood

Rule, 1 mm
Try square, 152 mm
Twist drill set

## AVAILABLE RESOURCES

The organizations listed below market metric materials for educators. Each produces one or more of the following aides: (1) books, (2) pamphlets, (3) film/filmstrips/slides, (4) kits, (5) posters, (6) charts, (7) periodicals, and (8) supplies and equipment.

Where possible, the organization has been placed under its appropriate product, but as many organizations produce a variety of materials, there may be overlap.

### BOOKS

Activity Resources Company, Inc.
Box 4875
Hayward, CA 94545

Allyn & Bacon, Inc.
470 Atlantic Avenue
Boston, MA 02210

American Association of School Librarians
1201 Sixteenth St., N.W.
Washington, DC 20036

AMJ Publishing Company
P.O. Drawer L.
Tarzana, CA 91356

American National Standards Institute
1430 Broadway
New York, NY 10018

American Technical Society
5608 Stony Island Avenue
Chicago, IL 60637

Behavioral Research Laboratory
P.O. Box 577
Palo Alto, CA 94302

Channing L. Bete Company, Inc.
45 Federal Street
Greenfield, MA 01301

Charles E. Merrill Publishing Co.
1300 Alum Creek Drive
Columbus, OH 43216

Coronet Films
65 East South Water Street
Chicago, IL 60601

Engineering Technology, Inc.
503 East Main Street
Mahomet, IL 61853

Glencoe Publishing Co., Inc.
17337 Ventura Boulevard
Encind, CA 91316

Grolier Educational Corporation
845 Third Avenue
New York, NY 10022

Houghton Mifflin Company
110 Tremont Street
Boston, MA 02107

The Instructor Publications, Inc.
Instructor Park
Dansville, NY 14337

J. J. Keller & Associates
145 W. Wisconsin Avenue
Neenah, WI 54956

Books (Continued)

Laidlaw Brothers
Thatcher and Madison
River Forest, IL 60305

Lapine Scientific Co.
6001 South Knox Avenue
Chicago, IL 60629

McGraw-Hill Book Company
1221 Avenue of the Americas
New York, NY 10020

Metric Association, Inc.
Sugarloaf Star Route
Boulder, CO 80302

Midwest Publications Co., Inc.
P.O. Box 129
Troy, MI 48084

National Aeronautics and Space Administration
Projects Office
S & E - ASTR - B/Building 4487
Marshall Space Flight Center
Huntsville, AL 35812

National Bureau of Standards
U.S. Government Printing Office
Washington, DC 20402

National Textbook Company
8259 Niles Center Road
Skokie, IL 60076

Random House
The School Division
457 Hahn Road
Westminster, MD 21157

Sterling Publishing Company, Inc.
419 Park Avenue, South
New York, NY 10016

Swani Publishing Company
Box 248
Roscoe, IL 61073

Jesse D. Wallace
1078 East 5th Avenue
Chico, CA 95926

John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10016

Willow House Publishers
111 N. San Joaquin Street
Stockton, CA 95202

## PAMPHLETS OR BULLETINS

The ABC'S Of SI
National Fluid Power Assoc.
P.O. Box 49
Thiensville, WI 53092

AISI Metric Practice Guide
American Iron & Steel Institute
1000 Sixteenth St., N.W.
Washington, DC 20036

Antitrust Implications of Metric Conversion
American National Standards Institute
1430 Broadway
New York, NY 10018

What About Metric?
Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

Measuring Systems and Standards Organizations
American National Standards Institute, Inc.
1430 Broadway
New York, NY 10018

Going Metric With the U.S. Printing Industry
Graphic Arts Research Center
Rochester Institute of Technology
Rochester, NY 14623

A Metric America: A Decision Whose Time Has Come
Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

Going Metric ... Pal, Programmed Assigned Learning
1078 East 5th Avenue
Chico, CA 95926

Metric Supplement to Science and Mathematics
Ideal School Supply Company
11000 South Lavergne Avenue
Oak Lawn, IL 60453

Metric Conversion Tables and Factors
Industrial Press, Inc.
200 Madison Avenue
New York, NY 10016

Handbook for Metric Conversion
Idaho Research Foundation, Inc.
University Station Box 3367
Moscow, ID 83843

Information on the Metric System and Related Fields
U.S. Metric Association
Sugarloaf Star Route
Boulder, CO 80302

Metric Conversion of Machine Tools
Swani Publishing Company
P.O. Box 248
Roscoe, IL 81073

Metric Editorial Guide
American National Metric Council
1625 Massachusetts Avenue, N.W.
Washington, DC 20036

Metric Style Guide
Council of Ministers of Education
252 Bloor Street West, Suite S 500
Toronto, Ontario Canada M5S1V5

Metric Yearbook
J. J. Keller & Associates, Inc.
Neehan, WI

Metrication
The Penton Publishing Company
Penton Plaza
Cleveland, OH 44114

Metrication--Legal & Trade Implications
Metric Conversion Paper 1
American National Metric Council
1625 Massachusetts Avenue, N.W.
Washington, DC 20036

Metrication--The Consumer Impact
Metric Conversion Paper 3
American National Metric Council
1625 Massachusetts Avenue, N.W.
Washington, DC 20036

Pamphlets or Bulletins (Continued)

Understanding the Metric System,
A Programmed Approach
Allyn and Bacon, Inc.
470 Atlantic Avenue
Boston, MA 02210

The International System of
Units (SI)
Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

Precision- A Measure of Progress
Public Relations Staff
General Motors Corporation
Room 1-101
General Motors Building
Detroit, MI 48202

Modern Metrics Made Easy
Clearvue, Inc.
6666 N. Oliphant Avenue
Chicago, IL 60631

SI Units and Recommendations for
The Use of Their Multiples and
of Certain Other Units
American National Standards
Institute
1430 Broadway
New York, NY 10018

Standard for Metric Practice
E380-1976 ASTM
1916 Race Street
Philadelphia, PA 19103

## AUDIO VISUAL

## FILM/FILMSTRIPS/SLIDES

## LOOPS/TRANSPARENCIES

Ideal School Supply Company
11000 South Lavergne Avenue
Oak Lawn, Il 60453

Introducing the Metric System BEA
Educational Media
2211 Michigan Avenue
Santa Monica, CA 90404

Library Filmstrip Center
3033 Aloma
Wichita, KS 67211

McGraw-Hill Company
1221 Avenue of the Americas
New York, NY 10020

Measuring the Metric Way
Encyclopedia Britannica
Educational Corporation
425 North Michigan Avenue
Chicago, IL 60611

Metric Weights and Measures
Library Filmstrip Center
3033 Aloma
Wichita, KS 67211

Metrics for Career Education
Encyclopedia Britannica
Educational Corporation
425 North Michigan Avenue
Chicago, IL 60611

Metrics on the Job and in the
Home
Clearvue, Inc.
666 Oliphant Avenue
Chicago, IL

Metrification in America
Educational Film Systems, Inc.
11466 San Vicente Blvd.
Los Angles, CA 90049

Modernized Metric System Series
Library Filmstrip Center
3033 Aloma
Wichita, KS 67211

The Metric System
Coronet Films
65 East South Water Street
Chicago, IL 60601

Eye Gate House, Inc.
146-01 Archer Avenue
Jamaica, NY 11435

National Microfilm Association
Suite 1101
8728 Colesville Road
Silver Springs, MD 20910

NBC Education Enterprises
30 Rockefeller Plaza
New York, NY 10020

Pathescope Educational Films, Inc.
71 Weyman Avenue
New Rochelle, NY 10802

Society for Visual Education, Inc.
1345 Diversey Parkway
Chicago, IL 60614

Swani Publishing Company
Box 248
Roscoe, Il 61073

Uniten Systems
246 West 34th Street
Indianapolis, In 46208

United Transparencies, Inc.
Box 688
Binghamton, NY 13902

## OTHER INSTRUCTIONAL AIDS

A. Balla & Company
3494 North Ocean Blvd.
Fort Lauderdale, FL 33308

American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103

Central Instrument Company
900 Riverside Drive
New York, NY 10032

Compu-Data Services, Inc.
16 Sherman Street
P.O. Box 471
Wayne, NJ 07470

Creative Publications
P.O. Box 10328
Palo Alto, CA 94303

C-Thru Ruler Company
6 Britton Drive
Bloomfield, CT 06002

Cuisenaire Company of America
12 Church Street
New Rochelle, NY 10305

Dick Blick Company
P.O. Box 1267
Galesburg, IL 61401

Educational Teaching Aids
159 West Kinzie Street
Chicago, IL 60610

Grolier Educational Corporation
845 Third Avenue
New York, NY 10022

Hobar Publications
1305 Tiller Lane
St. Paul, MN 55112

Houghton Mifflin Company
110 Tremont Street
Boston, MA 02107

Ideal School Supply Company
11000 South Lavergne Avenue
Oak Lawn, IL 60453

International Business Machines Corporation
Old Orchard Road
Armonk, NY 10504

John Colburn Associates, Inc.
P.O. Box 187
Lake Bluff, IL 60044

Leicestershire Learning Systems
Box 335
New Gloucester, ME 04260

Math Shop
5 Bridge Street
Watertown, MA 02172

Metric Aids Limited
75 Horner Avenue
Toronto 530,
Ontario, Canada

Metric Association, Inc.
Sugarloaf Star Route
Boulder, CO 80302

Metrication Task Group
George C. Marshall Space Flight Center
Huntsville, AL 35812

Metrix Corporation
P.O. Box 19101
Orlando, FL 32814

Mind/Matter Corporation
P.O. Box 345
Dansbury, CT 06810

National Education Association
P.O. Box 327
Hyattsville, MD 20781

National Science Teachers Association
1201 Sixteenth Street, N.W.
Washington, DC 20036

Other Instructional Aids (Continued)

Picket Industries
P.O. Box 1515
Santa Barbara, CA 93102

PITSCO
Box 1328
Pittsburg, KS

Spectrum Educational Ltd.
9 Dohme Avenue
Toronto, Ontario
Canada

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

Teach'em, Inc.
625 North Michigan Avenue
Chicago, IL 60611

Union Carbide Corporation
Public Relations Department
270 Park Avenue
New York, NY 10017

U.S. Metric Association, Inc.
Sugarloaf Star Route
Boulder, CO 80302

U.S. Metric Study Interim Report
Engineering Standards
U.S. Department of Commerce
National Bureau of Standards

## POSTERS AND CHARTS

American National Standards Institute
1430 Broadway
New York, NY 10018

Handyman's Reference Charts
Dept. MST, Roy G. Scarfo, Inc.
P.O. Box 217
Thorndale, PA 19372

The Instructor Publications, Inc.
Instructor Park
Dansville, NY 14437

JEM Innovations
4568 East 45th Street
Tulsa, OK 74135

Modern School Supplies, Inc.
Dept. JD, P.O. Box 958
Hartford, CT 06101

National Council of Teachers of Mathematics
1906 Association Drive
Reston, VA 22091

Polymetric Services
18324 Oxnard Street
Tarzana, CA 91356

Sargent-Welch Scientific Company
7300 North Linder Avenue
Skokie, IL 60076

## KITS

Edmund Scientific Company
380 Edscorp Building
Barrington, NJ 08007

Encyclopedia Britannica Educational Corporation
425 North Michigan Avenue
Chicago, IL 60611

International Tutors
Department A
22303 Devonshire
Chatsworth, CA 91311

Larry Harkness Company
115 North Princeton Avenue
Villa Park, IL 60181

National Science Teachers Association
1201 Sixteenth Street, N.W.
Washington, DC 20036

Science Service
1719 N. Street, N.W.
Washington, DC 20036

Swani Publishing Company
Box 248
Roscoe, IL 61073

## METRIC RESOURCES AND PERIODICALS

AMJ Publishing Company
Drawer L.
Tarzana, CA 91356
American Metric Journal SI
Metricpac

American Home Economics Assoc.
2010 Massachusetts Avenue, N.W.
Washington, DC 20036
Journal of Home Economics

American Industrial Arts Assoc.
1201 Sixteenth St., N.W.
Washington, DC 20036
Man/Society/Technology

American National Metric Council
1625 Massachusetts Avenue, N.W.
Washington, DC 20036
Metric Reporter

American National Standards Institute
1430 Broadway
New York, NY 10018
ISO Publications

American Vocational Association
1510 H Street, N.W.
Washington, DC 20005
American Vocational Journal

Beloit Tool Company
Swani Publishing Company
South Beloit, IL
U.S.A. Goes Metric

Graphic Arts Research Center
Rochester Institute of Technology
Rochester, NY
Going Metric With the U.S. Printing Industry

Weybright and Talley
New York, NY
Prepare Now for a Metric Future

J. J. Keller and Associates, Inc.
145 West Wisconsin Avenue
Neenah, WI 54956
Metric System Guide Bulletin

Key Markets Publishing Company
P.O. Box 4476
Rockford, IL 61110
Metric News

National Bureau of Standards
Metric Information Office
U.S. Department of Commerce
Washington, DC 20234

School Shop
Box 623, 416 Longshore Drive
Ann Arbor, MI 48107

Society of Manufacturing Engineers
Metric Information Center
20501 Ford Road
Dearborn, MI 48128

Superintendent of Documents
Government Printing Office
Washington, DC 20402

U.S. Metric Association, Inc.
c/o Louis Sokol
Sugarloaf Star Route
Boulder, CO 80302
U.S. Metric Association Newsletter

Superintendent of Documents,
U.S. Government Printing Office
NBS Publication 345
Washington, DC
A Metric America

# Some measurement unit Comparisons

## LENGTH

| Metric | | | Customary | | |
|---|---|---|---|---|---|
| 1000 millimeters | = | 1 meter | 12 inches | = | 1 foot |
| 100 centimeters | = | 1 meter | 3 feet | = | 1 yard |
| 1000 meters | = | 1 kilometer | 36 inches | = | 1 yard |
| | | | 5280 feet | = | 1 mile |

## WEIGHT

| Metric | | | Customary | | |
|---|---|---|---|---|---|
| 1000 grams | = | 1 kilogram | 438 grains | = | 1 ounce |
| 1000 kilograms | = | 1 metric ton | 16 ounces | = | 1 pound |
| | | | 2000 pounds | = | 1 short ton |

## VOLUME

| Metric | | | Customary | | |
|---|---|---|---|---|---|
| 1000 milliliters | = | 1 liter | 2 cups | = | 1 pint |
| 250 milliliters | = | 1 metric cup | 2 pints | = | 1 quart |
| | | | 4 quarts | = | 1 gallon |
| | | | 8 pints | = | 1 gallon |